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# COMPUTER WORK AIDS PHOTOGRAPHY FROM SURVEYOR I

The success of Surveyor I in taking television pictures of the Moon's surface has been further enhanced by a computer process developed at NASA's Jet Propulsion Laboratory, Pasadena, Calif.

The JPL process was applied to a dozen shots of most interest to scientists. Clear as most of Surveyor's 11,150 pictures were, the enhancement process brought out detail down to one-fiftieth of an inch in height.

Some of the enhancements apparently doubled the observable details. The flow pattern of dirt clods in one enhancement, for example enabled scientists to determine that they were scattered by the landing impact of one of Surveyor's footpads.

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The results were not totally unexpected. Moon photographs from the last three Ranger spacecraft missions had been intensified by the same process to show bumps three inches high on the lunar surface. The same technique was applied last year to Mariner IV pictures of Mars to bring out details of that planet.

These sharper prints are produced by a computerized system which corrects distortions and improves resolution in original photographs taken by television cameras. The system was developed by Dr. Robert Nathan - who led the JPL Video Digital-Computer Data Research for the National Aeronautics and Space Administration. Robert Selzer was in charge of Surveyor picture enhancement.

Quality enhancement is steadily being upgraded by computer research engineers at JPL, which the California Institute of Technology operates for NASA. Basically, they employ a large computer (IBM 7094) to filter out noise and frequency distortions in radio signals which send the pictures through space.

Mathematicians and computer programmers devise precise formulas and reduce them to computer instructions to remove blemishes from pictures. Other procedures stretch picture contrast, that is, they make dark areas darker and light ones lighter. The process cannot add features not originally photographed and recorded, but it clarifies details to an impressive degree.

The result has been a dramatic improvement in both lunar and martian picture resolution since Ranger VII first video-scanned the Moon for the United States in July, 1964. "We are removing the fog in our pictures of our planetary system," Nathan said.

Space scientists use the improved pictures for mapping as well as interpretive analysis. Enhanced Ranger pictures helped Surveyor project leaders to choose landing sites along the Moon's equator. Similarly, Surveyor enhancements should aid scientists to select the best site for landing astronauts in the Apollo program.

Computer enhancement began in 1963 after Nathan saw Russian pictures of the Moon's far side. "I was certain we could do much better," he recalls. "It was quite clear that extraneous noise had distorted their pictures and severely handicapped analysis."

In 1964 and 1965, Rangers VII, VIII and IX took more than 17,000 lunar pictures. On each mission, six television cameras transmitted picture data over the 235,000-mile distance from Moon to Earth in a few seconds. The Ranger series produced picture resolution up to 2,000 times better than Earth-based photos of the areas where the Rangers impacted.

Another JPL scientist, Thomas Rindflisch, developed the technique for taking into account the unique reflective properties of the lunar surface to produce topographic maps via the computer process.

The single vidicon camera aboard Mariner IV recorded 22 pictures of Mars in 26 minutes on July 14, 1965; picture resolution was two miles although snapped from distances over 7,400 miles. Playback transmission of each picture involved sending 240,000 bits of information in a period of 8½ hours. Mars was 134 million miles away from the Deep Space Network receiving stations on Earth.

Before the JPL team tackled the problem, space photo data analysis yielded about five per cent of the maximum potential. Now it is approaching 95 per cent. Much of the computer hardware development was done by Fred Billingsley, computer engineer, and John Morecroft, Mariner IV data specialist.

Some Ranger photographs have been reprocessed six or more times. Preliminary Mars picture processing lasted five months. During this period more than 3,000 computer instructions were written to correct flaws and 1,500 prints were made. From these came a file of 300 prints, which are still being upgraded.

The technique employs several steps. The vidicon signals from the spacecraft are recorded on magnetic tape with each impulse registered as binary digits, or bits, in computer language. Each six bits on the tape determines the darkness of a point. The digits (010101, 101110, etc.) represent 64 shades ranging from white to black.

The digital tape is fed into a computer which reconstitutes the image according to the points and lines of the vidicon system used. The computer compares lines by picking out and eliminating noise in the transmission. After electronic correction, the data are transferred to another magnetic tape. This is run through a film reproducer for the corrected photograph.

A new computer system is being set up to handle eight bits instead of six. An eight-bit system would provide 256 shades of gray in pictures and speed up processing. Billingsley expects the stepped-up system to be ready for 1967 Surveyor lunar scanning and the 1969 Mariner probe of Mars.

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